

Designing and Manufacturing SPARC Hardware in Australia

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*by Carlo Kopp
Chief Design Engineer
Computer Technology Design, Pty Ltd
Graphics Computer Systems, Pty Ltd*

ABSTRACT

Computer Technology Design (CTD), a GCS Group Company, has designed and produced an indigenous family of SPARC compatible products in Australia. This paper discusses the progress of this long term project, and looks at some of the development issues.

1. Introduction

In late 1991 the GCS Group of companies initiated a long term plan aimed at the eventual objective of achieving the capability to design and manufacture SPARC machines in Australia.

The companies' interest in having such a capability was long standing, unfortunately earlier attempts to secure access to the technology were not successful. Therefore a new plan was devised in late 1991, this plan was based upon an incremental multiphase strategy, starting out with chassis and integration components, to be followed by Sbus cards and motherboards, and finally culminating in the design and manufacture of processors and SPARC platform specific ASICs.

At the time the program started, the GCS group of companies had a support engineering capability, but lacked the infrastructure and tools required to carry out the design of hardware and integration of operating system software and driver software with the hardware, and the mechanisms required to support a manufacturing operation. Computer Technology Design Pty Ltd, a member of the GCS group, was formed with this purpose in mind.

The first products designed were simple, but aimed at yielding an immediate return on development time expended, and freeing CTD from dependency upon imported products. The first peripheral chassis products, the DeskPAC-5 and DeskPAC-20, started shipping by late 1991. These provided CTD with the means to integrate complete SPARC systems based upon imported SPARC motherboards and Sbus I/O cards.

The second phase products, Sbus frame buffer cards, were designed and prototyped in late 1992. At this time CTD formulated a fundamental policy for its product development, this being the requirement that SPARC International standards must be adhered to, and that established SPARC hardware design conventions and software development conventions be uncompromisingly adhered to.

The intention of this policy is to create products which are competitive alternatives to mainstream US SPARC vendors' products, without sacrificing either compatibility or quality of design.

The frame buffer boards have been very successful commercially, with several domestic production runs completed to date, and overseas sales are being negotiated at this time.

The first such product, a monochrome frame buffer, uses an ECL interface compatible with Sun-3 monitors and third party monitors. The second such product, a colour frame buffer, provides identical

video timing to the SPARCStation family, with sync on green video, and optional true grayscale operation. Both boards use the same video controller chip as Sun boards, and are wholly compatible with the Solaris BW2 and CG3 drivers respectively. A third frame buffer product is being designed at this time.

The third phase products, a family of Mbus SPARC motherboards, are currently in the final stage of prototyping and should be available in full scale production early next year.

2. Developing the MX - an Australian SPARC Machine

The emergence of the SPARC International Mbus standard, and the availability of Mbus chipsets and processor/cache modules with a wide range of price/performance ratios, provided the means to economically develop a family of motherboards with minimal resources.

Initial design studies for the MX motherboard family, internally designated the Mongoose machines, began in Q2 1992. Selection of a suitable motherboard chipset was a non trivial task, while definition of the board form factor and product positioning were no less challenging.

Three chipsets were initially evaluated. All offered a system topology structured around a 40 MHz, 64 bit wide Mbus, which provides the CPU/Cache module with access to memory, onboard I/O devices and the 20 MHz, 32 bit wide Sbus, which is the primary I/O channel for the system.

As such, all chipsets offered the potential for performance in the class of the Sun Galaxy and SPARCStation-10 platforms.

The principal selection criterion was compatibility with Solaris, and the ability to support Mbus level-2 transactions. An Mbus providing level-2 capability uses an arrangement with bus snooping caches which may be the owners of any given cache block of information, as such a performance advantage is gained in comparison with more orthodox write through caching strategies, where data consistency requirements force frequent invalidation of caches and hence flushing.

The requirement for compatibility dictated the use of identical I/O devices to those in existing SPARC machines, and biased selection in favour of chipsets with system topologies close to or identical to mainstream Mbus machines. The ability to support Sbus burst mode transfers was also considered, as this offered a substantial gain in DMA transfer rates to/from the SCSI and network interfaces.

Another key criterion was that the chipset supplier be a holder of a Solaris and an Open Boot PROM source tree licence. This was deemed to be of critical importance as it allows for rapid bugfixes, and the option of adding custom I/O devices.

The board form factor was another important development issue. Early studies centred on the Mongoose A design, which was to have been a plug-in board to fit into existing SLC and ELC systems. This was abandoned when it became apparent that the power supply and convective cooling in these machines were inadequate to support the superscalar second generation Mbus processor modules.

Subsequently, two form factors were chosen, an IPC/IPX compatible board, and a proprietary form factor to fit a low cost injection molded chassis originally designed for a desktop Intel machine.

By early 1993, hardware design work commenced on the Mongoose B, built around the Nimbus NIM-6000 chipset on an IPC/IPX board form factor. By the time the paper design was completed, Nimbus were experiencing financial difficulties, and this led to the abandoning of this design, in favour of another chipset.

The replacement designs, the Mongoose C and D, use IPC/IPX and proprietary form factors respectively, and use an Mbus Level-2 chipset with burst mode Sbus operation.

Two board layouts were thus implemented, using Cadence/Allegro schematic and layout tools, and prototype testing and debugging commenced six weeks ago. Both board designs are now running sundiag stress tests, with a mature port of Solaris 1.0 (4.1.2) and OBP 2.0. Porting work is being carried out now on SunOS 4.1.3 and OBP 2.9, to support second generation superscalar processors. The 4.1.3 port is now undergoing stress testing, with excellent results to date.

3. The Mongoose C/D Motherboard Design

The Mongoose C and D use an identical electrical design, which is a highly conventional Mbus/Sbus system topology. The Mbus connects a single Mbus slot, for a single or dual processor module, with a 64 bit wide main memory controller, and a 32 bit A.1 revision Sbus, with burst mode support.

The 64 bit wide parity main memory uses 36 bit SIMMs, to fit into small chassis, and has the capacity to fit up to 128 Mbytes of memory. While the chipset will support up to 256 Mbytes, the demand for cooling, board area and SIMM availability dictated a limit of 128 Mbytes.

All I/O devices are accessed through the MSI (Mbus Sbus Interface), which provides full Mbus Level-2 operation and Sbus burst mode operation. The MSI provides for five Sbus slots, one of which is dedicated to the onboard I/O (obio) E-bus eight bit channel. The Mongoose C/D uses one Sbus slot for an embedded CG3 colour frame buffer, and another is available for user applications. The CG3 frame buffer is 32 bit addressable, and provides both sync on green and grayscale video outputs.

The E-bus supports standard SPARCStation I/O devices, a bootprom, timekeeper NVRAM, two SCC serial devices with an RS-423 interface, an 8-bit audio channel and an i82077 floppy disk controller. ISDN, 16-bit audio and a parallel port were not included as these would incur a cost penalty which was not desirable given the target market for the product.

Following established SPARC design convention, Sbus slot 0 is occupied with a burst mode Sbus DMA controller, LANCE Ethernet controller and a FAS101 10 Mbyte/sec SCSI controller chip. The use of the established DMA+ chip with the LANCE controller is the only substantial topological difference from established Mbus machines, this allows for a substantially more compact installation with performance identical to the sun4c architecture SPARCStation-2.

The Mongoose C/D is therefore an optimised desktop workstation design, which balances lower aggregate I/O capability against cost. Users are not penalised by the cost of unused I/O slots and onboard I/O devices. No compromises were made in CPU to memory bandwidth, or in CPU to SCSI channel bandwidth, as these were deemed critical performance criteria.

4. The Mongoose Solaris Port

The Mongoose C/D will be initially supplied with Solaris 1.1 (SunOS 4.1.3) and Open Boot PROM 2.9. The port of OBP 2.9 is currently under way, this is the latest revision of OBP and it supports the latest Sbus cards.

The port of SunOS 4.1.3, carried out in Melbourne, is currently in alpha test, and will support both the Fujitsu/Ross Pinnacle (HyperSPARC) and Texas Instruments Viking (SuperSPARC) superscalar processors.

The changes to the OS kernel are trivial, and most of these are confined to three files in the /sys/sun4m directory. These modules required remapping of timer and system interrupt registers to accommodate chipset specific register mappings. The ethernet LANCE driver was slightly modified to accommodate the sun4c style DMA controller hardware.

The operating system will therefore be indistinguishable, from a user's perspective, from the SunSoft CDROM binary release, including the ability to accommodate standard Sbus cards and their drivers. A single bootprom will accommodate both Mbus processor module types, allowing 'plug and play' processor module upgrades. The use of 4.1.3 provides full Mbus Level-2 functionality, as well as device driver support for the new FAS101 fast SCSI controller and i82077 floppy controller.

A port of Solaris 2.3 (System V) is planned for early next year, again to run with the 2.9 OBP port. Solaris 2.3 will cater for those sites which do not wish to use the BSD derived Solaris 1 Operating System.

5. Manufacturing

The Mongoose machines will be manufactured in Australia. The 8 layer printed circuit boards use 0.007" track technology, and prototypes have been fabricated by two different PCB houses in Australia.

Boards will be loaded with components and tested locally, and final assembly carried out in Melbourne. Power supplies for the Mongoose D will be manufactured in Melbourne by Setec Pty Ltd, who designed the 5.25" form factor supply to CTD specifications.

Experience with manufacturing locally has been mixed. Areas where Australia can compete successfully are hardware design and software development, loading of PCBs with components and testing of boards, and final assembly and test of equipment.

CTD purchase most of their Silicon directly in the US, as local prices and leadtimes are in most instances, uncompetitive. ICs are sourced locally only from those suppliers, who are able to offer internationally competitive prices and leadtimes.

Printed circuit boards will be sourced in Australia, where possible, in spite of uncompetitive pricing, as the fractional cost of the PCB in the aggregate build cost of the machine is not great. This will increase Australian content and provide better control over the manufacturing process.

Metalwork will also be sourced locally. The experience to date has been that metalwork, in spite of being the technologically simplest component of the process, is the most difficult to source locally. CTD have managed to maintain internationally competitive quality only by instituting draconian QA procedures for metalwork and carefully selecting suppliers. Some suppliers achieved consistent reject rates in excess of 50% and were subsequently dropped. Of interest, in relation to domestic metalwork manufacturing, is the fact that CTD must have screws and other fasteners manufactured to order, as the required sizes are not stocked.

The Mongoose D will only use imported electronic components and its plastic case, thus achieving what CTD believe will be the highest Australian content in any locally available workstation product.

Hardware design maintenance and Operating System maintenance will be carried out locally by CTD. The modular design of the Mongoose family of machines is expected to provide a life cycle of several years, with progressive upgrades to the chipset and field replacement of processor modules to provide customers with smooth upgrade paths for installed systems.

6. Summary

CTD have locally designed a SPARC Mbus motherboard product, using the latest generation of SPARC Mbus technology. CTD intend to manufacture these machines in Australia, for sale into the export and domestic markets.

CTD have demonstrated that it is possible to both develop and manufacture SPARC technology based products in Australia, and while many obstacles do exist, they are not insurmountable.